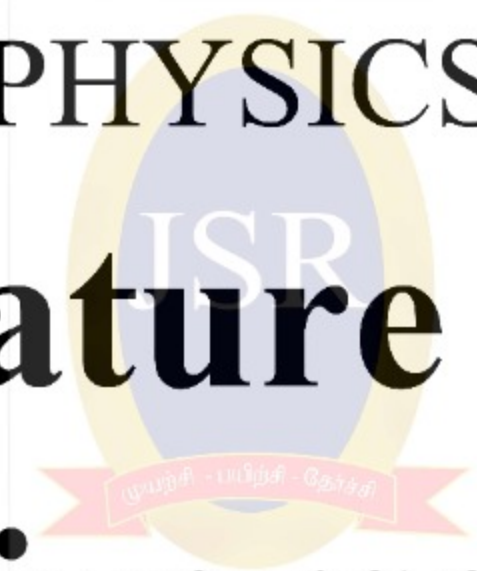


# JSR IAS ACADEMY

## GENERAL SCIENCE

### PHYSICS

# Nature of Universe - I



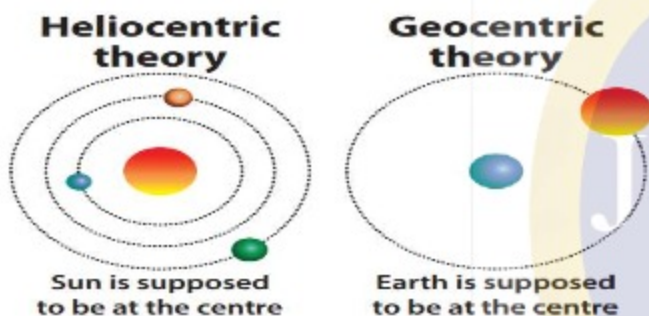
- ❖ The field of study of the universe is called **astronomy**.
- ❖ **Universe** is commonly defined as the **totality of everything that exists or is known to exist**.
- ❖ Even though the **spatial size of the entire universe is still unknown**

### Geocentric model

- ❖ Earth is the centre of all the objects in the space. This was known as the geocentric model, held by **Greek astronomer Ptolemy (2nd Century)**, **Indian astronomer Aryabhata (5th Century)** and many astronomers around the world.

### Heliocentric model

- ❖ Later Polish astronomer **Nicolaus Copernicus** proposed the **heliocentric model (helios = Sun)**, with Sun at the centre of the solar system.
- ❖ **Invention of the telescope** in the Netherlands, in **1608**, created a revolution in astronomy.



### GEO Centric Theory

- ❖ Sun, Moon, stars all **appear to rise in the East and move towards the west**, giving us an impression that all these objects are going around the Earth.
- ❖ Earth is spinning and that is why Sun, Moon and stars appear to go around the Earth.
- ❖ **Two observations** supported the idea that Earth was the center of the Universe.
- ❖ **First**, from anywhere on the Earth, the Sun appears to revolve around the Earth once in a day.
- ❖ **Second**, the Earth seems to be unmoving from the perspective of an earthbound observer; it feels stationary.

### Aryabhata

- ❖ Aryabhata said that **Earth is spinning in its axis**, that is the cause of **apparent daily motion from East to West**.

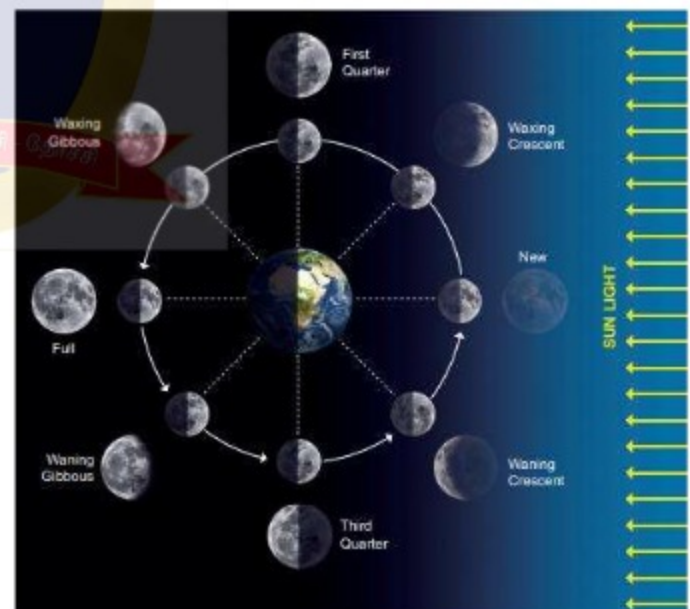
- ❖ In Greece, this model was put forth by the **Greek philosopher Plato** and his disciple **Aristotle in 6th century B.C.**
- ❖ It was standardized by a **Greeco Roman mathematician Ptolemy** in the 2nd Century A.D.
- ❖ A similar model is seen in the **Siddhanthic astronomy in India** like **Aryabhateeyam** of **Aryabhata**.
- ❖ **The Purananuru (65)** of Sangam literature, the **Poet Kalathalaiyar** singing in appreciation of **Cheraman Peruncheralathan** says
- ❖ “On the day when the **full moon appears**, the **sun and moon look at each other** with their bright light. In the evening time, one sphere hides behind the mountains.”

**On the full moon day**, when the Sun is setting in the west, precisely at the same time, Moon rises at the East. That is both Sun and Moon are in the opposite side.

Likewise when it is **waning half moon**, the **Moon is rises** when it is **midnight** and the **waxing half moon rises during noon**.

### Half moon

- ❖ first and third quarter moon
- ❖ one half of Moon is illuminated by Sun and the opposite side is shroud in darkness.



**when the moon is positioned between the earth and sun**

- ❖ illuminated part of Moon is away from Earth.
- ❖ Hence we cannot see any part of the illuminated side of the Moon.

- ❖ Only the dark side of Moon is towards Earth.
- ❖ When the moon is in this position, we have new moon.

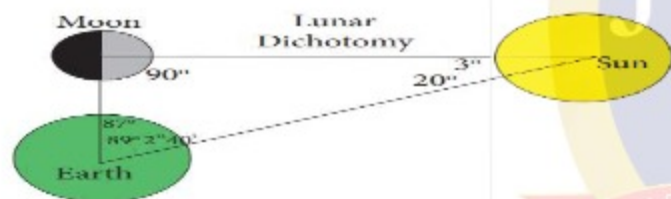
#### Now look at the moon when it is behind the Earth

- ❖ Now the portion of the moon illuminated by sun is totally towards Earth.
- ❖ The dark side is away from the Earth.
- ❖ This means the moon will appear to be round in the sky. This is full moon.



#### When the Sun, Earth and Moon are in 90 degree angle how will the moon appear to a person on the surface of the Earth?

- ❖ Now if you look at the portion of moon facing Earth, we will see **half if it illuminated and half is dark side.**
- ❖ Thus, the moon will appear as half moon.
- ❖ The half moon **during the waxing period is called as first quarter** and the half moon **during the waning period is called as third quarter.**



#### Crescent

refers to the phases where the **moon is less than half illuminated.**

#### Gibbous

refers to phases where the **moon is more than half illuminated.**

#### Waxing

“growing” or expanding in illumination,

#### Waning

“shrinking” or decreasing in illumination.

- ❖ Moon going around Earth with **27 day period** nicely explained its motion.

#### Geocentric model

The simple **geocentric model**, where planets go around the Earth could not explain why the brightness of the planets changed, and why they reversed their directions.

#### Epicycle model

To explain the puzzling phenomena astronomers in early times proposed a **change in the simple geocentric model**. This is called as epicycle model.

- ❖ **Ptolemy** (2nd cent) in Greece, **Aryabhatta** in India and others used the epicycle model to explain the motion of the celestial objects.
- ❖ **Their models were improved by** generation of astronomers like **Tycho Brahe** and **Neelakanta Somayaji**.

#### Arrival of telescope

- ❖ Telescope was invented by **Hans Lippershey**
- ❖ But **Galilio** used it for studying the sky for the first time.

Galilio was **able to see mountains on the Moon, small dim stars invisible to naked eye, sunspots on the face of Sun.**

He was able to **demonstrate that the milky way, an hazy bright patch in the sky is nothing but thousands of stars huddled together,**

- ❖ **Jupiter had moons** going around it
- ❖ **Saturn** had mysterious appendage which we now know as **rings.**
- ❖ One of the most startling observations he made was related to telescopic observation of **Venus.**

This convinced him to accept the theory of the **Polish Astronomer Nicolus Copernicus**, that it is not Sun, planets and Stars that go around Earth, but it is **Earth and other planets that go around the Sun-heliocentric theory.**

#### Heliocentric model

**Earth orbit** around Sun in **365 days**, whereas **Mars takes 687 days.**

#### Venus

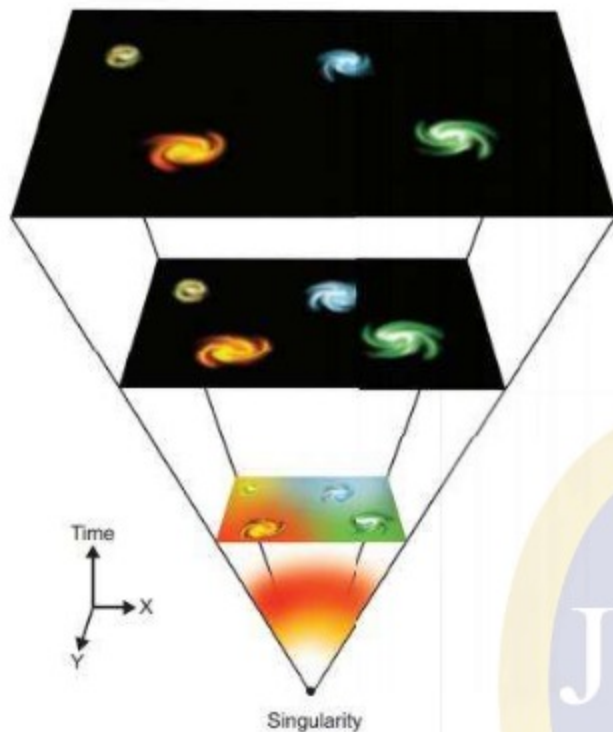
- ❖ Galileo **observed Venus in 1610-1611** with a telescope.

#### Origin of the Universe

- ❖ Our Sun is a star with a planetary system.



- ❖ Billions of such stars constitute a system called as galaxy.
- ❖ The name of our galaxy is, Milky Way. Like Milky Way, there are at least hundreds of billions of galaxies in the Universe.
- ❖ The event when the matter confined in a single point and began to expand is called 'big bang'.



- ❖ At that stage of the evolution of the Universe, it was filled with clouds of hydrogen and helium gas.
- ❖ Giant clouds of hydrogen and helium were gradually drawn to the places where dark matter was most dense, forming the first galaxies, stars, and everything else seen today.
- ❖ We cannot see anything that happened during the first 300000 years of the Universe.
- ❖ The only direct evidence of the Big Bang itself is a faint glow in space, called cosmic microwave background.
- ❖ Finally, about 100 million years after the Big Bang, the gas became hot and dense enough for the first stars to form.
- ❖ New stars were being born at a rate 10 times higher than in the present-day Universe.

### Galaxies

A galaxy is a large collection of stars or cluster of stars and celestial bodies held together by gravitational attraction.

Most galaxies range from thousand to ten thousand parsec in diameter.

**Astronomical unit :** The average distance between the Earth and the Sun is called an astronomical unit. It is denoted by 'au'.

$$1 \text{ au} = 1.496 \times 10^8 \text{ km}$$

**Light year :** The distance travelled by light in one year is called a light year. It is denoted by 'ly'.

$$1 \text{ ly} = 9.4607 \times 10^{12} \text{ km}$$

**Parsec:** A parsec is defined as the distance at which one astronomical unit subtends an angle of one arc second. It is denoted by 'pc'

$$1 \text{ pc} = 3.2615 \text{ ly} = 3.09 \times 10^{13} \text{ km}$$

### Types of galaxies

There are various types of galaxies such as spiral, elliptical, barred spiral and irregular

### Spiral Galaxy

- ❖ Spiral galaxies consist of a flat, rotating disk containing stars, gas and dust, and a central concentration of stars known as the bulge.

### The Big Bang Theory

- ❖ Under this theory, space and time emerged together about 14 billions of years ago.
- ❖ At that time, the entire Universe was inside a bubble that was thousands of times smaller than a pinhead.
- ❖ It was hotter and denser than anything we can imagine.
- ❖ Then it suddenly expanded.
- ❖ In a fraction of a second, the Universe grew from smaller than a single atom to bigger than a galaxy.
- ❖ And it kept on growing at a fantastic rate. It is still expanding today.
- ❖ Over the next three minutes, the temperature dropped below 1 billion degrees Celsius.
- ❖ After 300 000 years, the Universe had cooled to about 3000 degrees.
- ❖ Atomic nuclei could finally capture electrons to form atoms.



- ❖ These are often **surrounded by a much fainter halo of stars.**
- ❖ Spiral galaxies are **named by their spiral structures that extend from the center into the galactic disc.**
- ❖ The spiral arms are sites of ongoing star formation and are **brighter than the surrounding disc** because of the young, hot stars that inhabit them.



### Elliptical Galaxy

- ❖ An elliptical galaxy is a **type of galaxy having an approximately ellipsoidal shape and a smooth image.**
- ❖ elliptical galaxies are **three-dimensional, without much structure, and their stars are in somewhat random orbits around the center.**
- ❖ Interestingly Stars found inside of **elliptical galaxies are on an average much older than stars found in spiral galaxies.**
- ❖ Elliptical galaxies tend to be **surrounded by large numbers of globular clusters.**



### Irregular Galaxy

- ❖ An irregular galaxy is a **galaxy that does not have a distinct regular shape, they are often chaotic in appearance, with neither a nuclear bulge nor any trace of spiral arm structure.**
- ❖ About **one forth of the galaxies found so far are of this type.**
- ❖ Cosmologists say that **some irregular galaxies were once spiral or elliptical galaxies but were deformed by an uneven external gravitational force.**

- ❖ Irregular galaxies may **contain abundant amounts of gas and dust.**



### Barred Spiral

- ❖ A barred spiral galaxy is a **spiral galaxy with a central bar-shaped structure composed of Stars.**
- ❖ Bars are **found in approximately in two-thirds to one third of all spiral galaxies.**
- ❖ The Milky Way Galaxy, where **our own Solar System is located, is classified as a barred spiral galaxy.**



The Hubble Space Telescope and powerful ground-based telescopes are now beginning to find galaxies that were created about one billion years after the Big Bang. These small galaxies were much closer together than galaxies are today. Collisions were common. Like two flames moving towards each other, they merged into bigger galaxies. Our Milky Way galaxy came together in this way.





**Milky Way**

- ❖ The Milky Way is the **galaxy in which our solar system is located.**
- ❖ The **diameter of Milky Way is over 100,000 light years.**
- ❖ It is also thought to contain at least 100 billion stars.
- ❖ The galaxy that is **closest to our Milky Way is Andromeda.**
- ❖ In **Indian mythology**, this patch called as **Akasha Ganga.**
- ❖ From the Earth, the **Milky Way appears as a band because its disk-shaped structure** is viewed from within.
- ❖ **Galileo Galili first resolved the band of light into individual stars with his telescope in 1610.**
- ❖ Until the early 1920s, most astronomers thought that the Milky Way contained all the stars in the Universe.
- ❖ Observations by **Edwin Hubble** showed that the Milky Way is just one of many galaxies.
- ❖ The Milky Way does not sit still, but is constantly rotating.
- ❖ Our solar system is located within the disk of the galaxy, about 27,000 light years away from the centre of the galaxy.
- ❖ The solar system travels at an average speed of 828,000 km/h.
- ❖ Even at this rapid speed, the solar system would take about 230 million years to travel all the way around the Milky Way.
- ❖ When the solar system was in the same spot as it is now, there were no humans, no Himalayan mountain on Earth and the dinosaurs were roaming around the Earth.
- ❖ Tucked inside the very center of the galaxy is a monstrous black hole, billions of times as massive as the sun.
- ❖ Although, black holes cannot be directly viewed, scientists can see their gravitational effects
- ❖ most galaxies, like our milkyway, are thought to have a black hole in their heart.

**Constellation**

- ❖ A constellation is a **recognizable pattern of stars in the night sky when viewed from the Earth.**
- ❖ **International Astronomical Union** has classified 88 constellations to cover the entire celestial sphere.

- ❖ Many of the old constellations have Greek or Latin names and are often named after mythological characters.

**Ursa Major (Saptha Rishi Mandalam)**

- ❖ a large constellation and it covers a large part of the sky.
- ❖ The most striking feature of this constellation is a group of seven bright stars known as **big dipper (seven Sages in Indian astronomy).**
- ❖ Ursa Minor in Latin means 'the little bear' it lies in the northern sky.
- ❖ The Pole star – Polaris (Dhruva) lies within this constellation.
- ❖ The main group, 'little dipper', consists of seven stars and is quite similar to that found in Ursa Major.
- ❖ **Orion** was a hunter in Greek mythology.
- ❖ The constellation comprises around 81 stars out of which all but 10 are too faint to be seen with naked eye.

| Name of Constellations |              |
|------------------------|--------------|
| Indian Name            | English Name |
| Mesha                  | Aries        |
| Rishabha               | Taurus       |
| Midhunam               | Gemini       |
| Kadaka                 | Cancer       |
| Simha                  | Leo          |
| Kanni                  | Virgo        |
| Thula                  | Libra        |
| Vrischika              | Scorpio      |
| Dhanu                  | Sagittarius  |
| Makara                 | Capricorn    |
| Kumbha                 | Aquarius     |
| Meena                  | Pisces       |

**Stars**

- ❖ A Star is a luminous heavenly body that radiate energy.
- ❖ With naked eyes, we can see nearly 3000 stars in the night sky
- ❖ The atmosphere disturbances do not allow light to reach us in a straight line path. Because of this the stars appear to twinkle.
- ❖ The Sun is the nearest star to the Earth.
- ❖ The next nearest star is Alpha Centauri